Miniature Guinier X-ray Diffraction Instrument for Planetary Exploration.

Completed Technology Project (2015 - 2018)

Project Introduction

We propose to develop a concept of Guinier Camera for high-resolution X-Ray Diffraction (XRD) analysis in planetary exploration. The technology inherits from the CheMin instrument (XRD on-board the MSL rover) and a number of XRD instruments developed by this team under various NASA grants (PIDD, ASTID, SBIR). The main innovation over prior instruments is the capability to obtain high resolution XRD data and high throughput by using parafocusing diffraction geometries. This helps addressing limitations of the current planetary XRD with regard to phase identification in complex mineralogies, such as those recently observed with the CheMin instrument. Both transmission and reflection instruments can be achieved with this Guinier concept, offering a range of potential applications from on-board instrument for powder analysis (similar to CheMin on MSL) to in-situ analysis of rocks and regoliths with limited to no sample preparation. Most modern laboratory XRD instruments use parafocusing in a layout difficult to apply in the context of space-flight due to the X-ray source and detector precision scanning requirements. We propose to develop a planetary parafocusing XRD without moving part based on curved 2D detectors in geometries known as Seeman-Bohlin or Guinier. These geometries were developed for high-resolution film-based XRD instruments. Guinier geometries are still used today in synchrotron beamline instruments for high-resolution time-resolved XRD studies. The main technical challenge of the proposed work is the design, fabrication and implementation of a digital solid-state 2D X-ray detector to replace films and image plates traditionally used with these geometries. Several technical options will be investigated based on Charge-Coupled Devices (CCD): 1 — a curved CCD sensor, developed in collaboration with the CCD manufacturer E2V, 2 — a combination of polycapillary X-ray optics and X-ray sensitive flat CCD, 3 — a combination of cylindrical phosphor, fiber optics coupler and light-sensitive flat CCD. All three configurations will be investigated, prototyped and evaluated. Transmission geometries impose a focused incident X-ray beam, as opposed to reflection geometries which require a divergent beam as produced by a micro-focused X-ray tube. Another technical aspect of this research will be the evaluation of technologies for bending the divergent beam of a micro-focused tube into the required convergent beam. Mineralogy is key to the exploration of the solar system. Our instrument concept serves future landed missions for robotic planetary exploration. The technology could also derive into astronaut field instruments for human exploration. Our concept offers the potential for substantially improved performance over the instrument currently on Mars. We anticipate TRL 3-4 to be achieved at completion of this work, at which point it will be proposed for technology maturation under MaTiSSE.

Anticipated Benefits

The miniature Guinier XRD will provide higher resolution in-situ mineralogical analysis of rocks and soils than available from current planetary XRD instruments.

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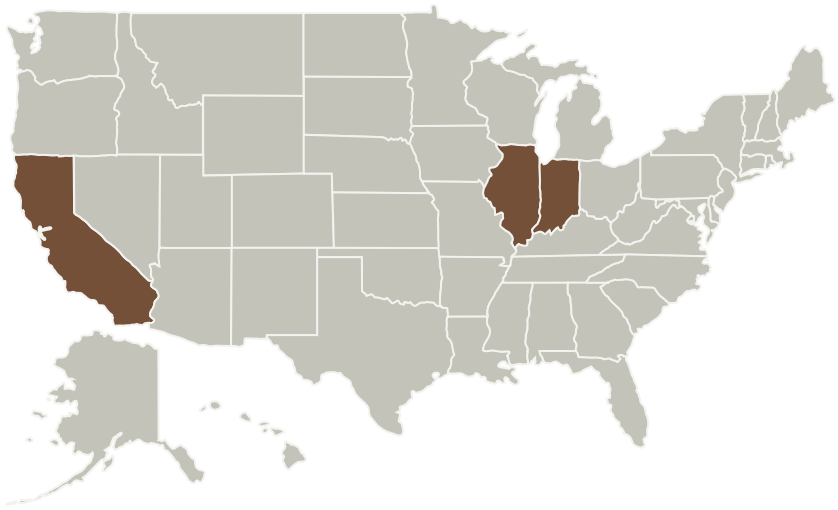
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
SETI Institute(SETI)	Lead Organization	Academia	Moffett Field, California

Primary U.S. Work Locations	
California	Illinois
Indiana	

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

SETI Institute (SETI)

Responsible Program:

Planetary Instrument Concepts for the Advancement of Solar System Observations

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Haris Riris

Principal Investigator:

Philippe C Sarrazin

Co-Investigators:

Marc Gailhanou
David F Blake
Przemyslaw K Dera
Barbara E Vance
David L Bish
Thomas F Bristow

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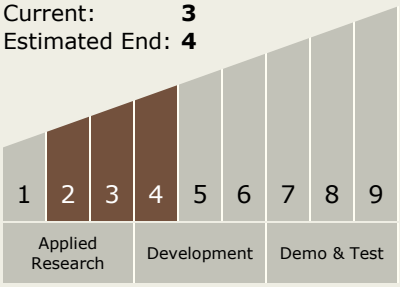
Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **4**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.4 Environment Sensors

Target Destination

Others Inside the Solar System